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ABSTRACT

This study examined the question of whether the integration of abstract and realistic visualization can improve the effectiveness of visualized instruction. Two methods of integrating visualizations were investigated. The first method used hybrid illustrations, i.e., a real color photograph into which a line drawing segment has been inserted. This provided an abstract illustration of the important relevant elements to be communicated, as well as an arousing realistic context. The second method was through the simultaneous presentation of both a line drawing and a real color photograph. In this treatment the abstract line drawing could communicate the essential information and/or facilitate looking at the realistic illustrations. Subjects for the study were 490 tenth grade students enrolled in a mandatory health class. The instructional script dealt with the construction and operation of the heart and was accompanied by 37 visuals, designed to illustrate concepts and relationships for which visualization is likely to be beneficial. The results suggest that designers of visualized instruction may expect to enhance its effectiveness under general conditions by inclusion of realistic visualization. However, the inclusion of abstract visualization or the integration of abstract and realistic visualization should be based on such considerations as pacing, general ability, and the type of instructional objective. (Author/RAO)

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The Instructional Effectiveness of Integrating Abstract and Realistic Visualization

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The Instructional Effectiveness of Integrating Abstract and Realistic Visualization

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The relative effectiveness of abstract and realistic visualization is debated in the literature and by practitioners. The study examined the instructional effectiveness of integrating abstract and realistic visualization for self-paced and externally-paced instruction involving five types of instructional tasks and students of different general ability.

The results suggest that designers of visualized instruction may expect to enhance its effectiveness under general conditions by inclusion of realistic visualization. However, the inclusion of abstract visualization or the integration of abstract and realistic visualization should be based on a consideration of pacing, general ability, and the type of instructional objective.

The Instructional Effectiveness of Integrating Abstract and Realistic Visualization

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Paper presented at the 1979 Annual Convention
Association for Educational Communication and Technology
Research and Theory Division

New Orleans, Louisiana March 7, 1979

Purpose

This study examined the question of whether the integration of abstract and realistic visualization can improve the effectiveness of visualized instruction. The question is derived from the perennial issue of the relative worth of realistic and abstract visuals. Whether reality, with its myriad of cues which are not directly relevant to a particular learning objective, is a more effective aid to communication than some edited representation of reality is still debated by practitioners and researchers.

The general preference for realism in educational practice is reinforced by several theorists. Dale's (1946) "Cone of Experience" has been particularly influential. Carpenter's (1953) "Sign Similarity Hypothesis" regarding film effectiveness and Morris' (1946) "Iconicity Theory" are also supportive of the notion. Dwyer refers to these as "realism theories."

The preference is also based partly on the affective value of realistic visuals. That is, they are expected to arouse interest and gain and sustain attention. This intuitive basis is supported somewhat by findings of a general preference for complex detailed illustrations, particularly by older children and adults (French, 1952; Spaulding, 1955; Hanes, 1973).

Dember (1960) discussed basic research which also suggests that complexity is a "major determinant of attention and exploration in both animals and man" (p. 352). Yarbus (1967), Kahneman (1973), and Haber (1973) cite related evidence that complex areas of visuals attract attention. Dember (1960) also provides evidence that stimulus complexity constitutes a rewarding condition.

Travers (1964, 1970), Dwyer (1972), and others argue, alternatively, that an increase in realism will not necessarily lead to increased learning. These later researchers feel that the irrelevant cues may interfere with learning. Travers (1964) advocates that the discarding of less important information and the retention of more important should be done <u>for</u> the learner to assure effectiveness (pp. 380-382). Gibson agrees that line drawings render the most important visual properties of an object, "the form, shape, and proportion of its edges and surfaces." He suggests that, "If we assume that a perceiver does not need to be given <u>all</u> the properties of an absent object in order to know how to deal with it, but only those which are <u>relevant</u> or <u>significant</u>, it is a waste of effort to simulate them all" (1954, pp. 21-22). Hochberg also suggests that "the characteristics of a given object may be communicated better as the representational fidelity of the surrogate deteriorates" (1962, p. 30). Dwyer (1972) found evidence to support this notion under certain conditions.

Broadbent (1958, 1965) and Travers (1964, 1970) see this inability to handle excess detail as a function of the limited capacity of the human information processing system. Broadbent describes a system in which irrelevant information is "filtered" through selective attention.

Dwyer found that the type of visual illustration (abstract vs realistic) which was most effective for instruction was dependent upon the type of information to be transmitted (or, the kind of objective), whether the instruction was self-paced or externally paced, the grade level, and the level of entering behavior of the students (1972). The type of illustration most effective was also found to be dependent on the level of general ability (IQ) (1976). For certain educational objectives, Dwyer found no significant differences between verbal only and visualized treatments (1972).

The purpose of this study was to investigate the possibility that presentations which integrate realistic and abstract visualization might prove effective under more general conditions with respect to the learner, content and presentation. Two methods of integrating the visualization were investigated. The first method was with the hybrid illustration, a real color photograph into which a line drawing segment has been inserted. This provided an abstract illustration of the important relevant elements to be communicated, as well as an arousing realistic context. The second method was through the simultaneous presentation of both a

line drawing and a real color photograph. In this treatment the abstract line drawing could communicate the essential information and/or facilitate looking at the realistic illustration. The realistic illustration, on the other hand, could motivate and arouse as well as communicate essential information and relate it to reality. The effectiveness of these treatments was measured for various kinds of learning objectives, different general learning ability, externally-paced and self-paced methods of instruction, and immediate and delayed retention.

Procedure

Subjects were 490 tenth grade public school students enrolled in mandatory health classes. Classes were coeducational and there was no ability grouping. The subjects were stratified into high, medium and low general ability groups on the basis of their scores from the Analysis of Learning Potential test. All subjects received a general physiology pretest prior to instruction. The instructional unit and criterion tests were those developed and used by Dwyer (1972). The 2,000 word instructional script deals with the construction and operation of the heart and is accompanied by 37 visuals, designed to illustrate concepts and relationships for which visualization is likely to be beneficial.

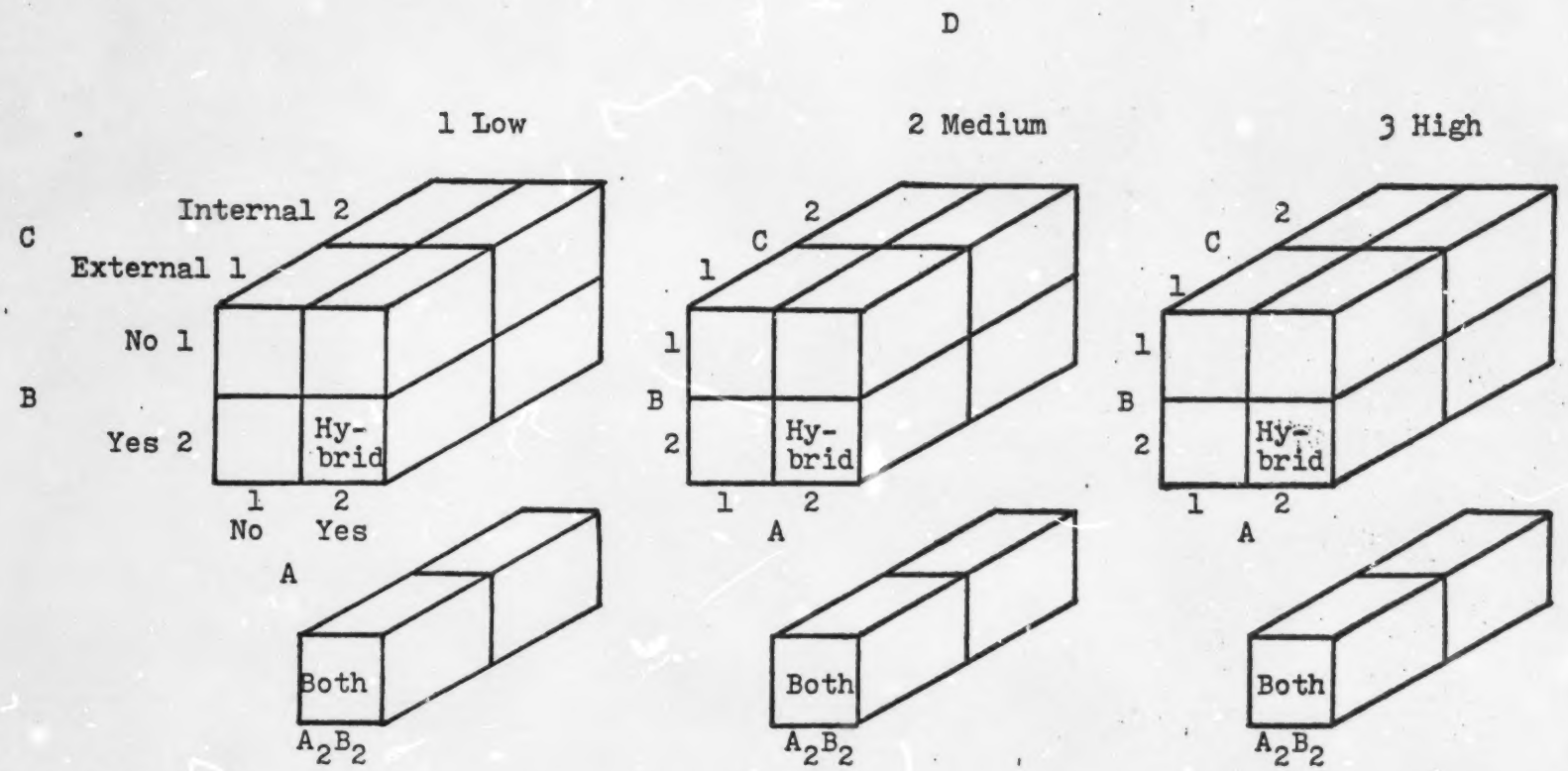
The criterion tests were a drawing test with 18 items and identification, terminology and comprehension tests with 20 items each. Together these four tests constituted a total criterial test. Reliabilities (KR-20) of the individual tests equal or

exceed .76. The reliability of the total test is .91, according to Dwyer (1972, p. 12).

Half of the subjects received self-paced written instruction and half received externally-paced instruction by an audio tape recording (with visuals in booklet form). Within each of these two modes the students received one of the five treatments: instruction with simple line drawings, instruction with realistic color photographs (3X5 inches), instruction with both line drawings and color photographs, instruction with hybrid illustrations of realistic photograph and line drawing segments, and a control group with no visuals. Treatments were randomly assigned to subjects. All students received the four-part criterion test on the day immediately following the instruction and again after four weeks.

The two methods of integrating abstract and realistic visualization were each separately compared with the control group, the realistic visualization treatment group and the abstract visualization treatment group. These separate comparisons constituted a set of contrasts in a two-by-two matrix formed by the absence or presence of realistic visualization versus the absence or presence of abstract visualizations. This analysis model was chosen in order to facilitate identification of the anticipated additive effect of integration as an interaction of two factors.

The primary analysis involved a five-factor mixed design denoted RS_n in $(A_2 @ B_2 @ C_2 @ D_3) @ J_4$ (See Figure 1). Random



A = Realism
B = Abstraction
C = Mode
D = General Ability

RS_n in $(A_2 @ B_2 @ C_2 @ D_3) @ J_4$

Figure 1. Primary experimental design.

subjects were nested in cells formed by the four factors:

Factor A: Two levels of the realism variable,
1) no realism and, 2) realistic visualization.

Factor B: Two levels of the abstraction variable,
1) no abstraction and, 2) abstract visualization.

Factor C: Two levels of the presentation mode variable, 1) externally-paced and, 2) internally-paced.

Factor D: Three levels of the general ability variable,
1) Low, 2) Medium and 3) High.

All subjects are crossed with four levels of the dependent criterion variable (Factor J), 1) drawing test score, 2) identification test score, 3) terminology test score and, 4) the comprehension test score. A total criterion test score which combined the other 4 scores was analyzed separately. Scores on these tests were transformed to standard scores before analysis of results to assure comparability of the scores.

Because two methods of integrating realistic and abstract visualization were being contrasted, the entire design was analyzed twice with one oblong formed by the A and B factors (i.e., A_2 B_2) being changed A total of 30 cells are involved in the study.

A separate analysis was used to compare the two methods of integrating abstract and realistic visualization across the pacing and general ability factors. This secondary design was denoted $RS_n(A_2' @ B_2' @ C_3') @ J_4$ (See Figure 2).

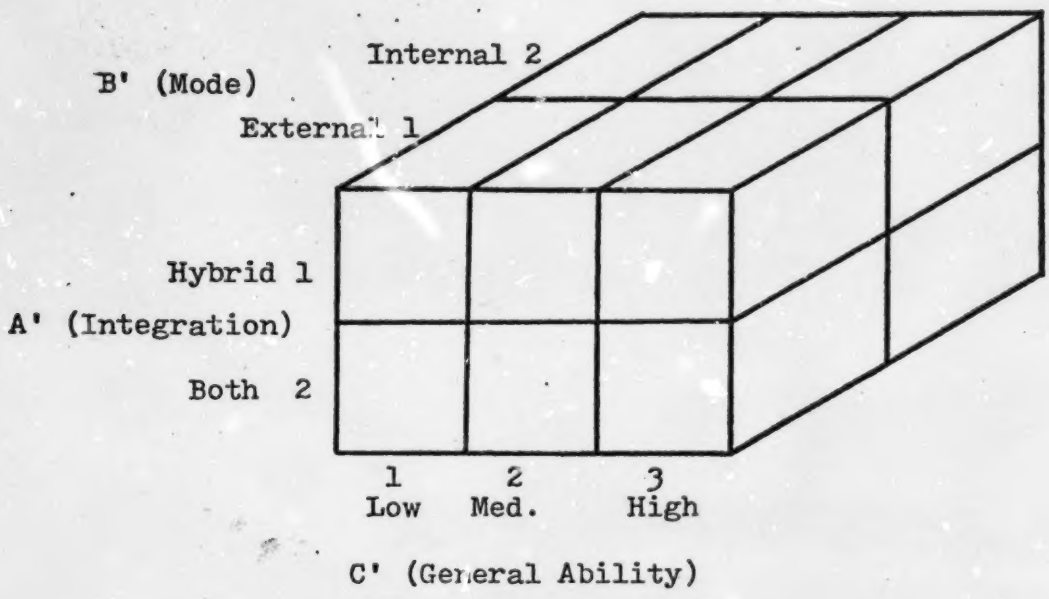


Figure 2 Secondary Experimental Design

The library program ANOVR was used for the principal analysis of variance computations. This program will analyze up to four between subjects factors and up to four within subject factors in a single design. The library program FOLUP was used for the follow-up comparisons of means after significant F tests. The Tukey Wholly Significant Difference test was specified in order to control the family-wise risk of error of falsely rejecting a true null hypothesis (type I error).

Results*

In the analysis of variance procedures for both the immediate and delayed posttests, the two-way interaction effects which compared the four types of visualization were non-significant. In the analyses comparing the two methods of integrating abstract and realistic visualization the main effects of interests were similarly non-significant. Accordingly, the analysis of both the immediate and delayed posttest scores failed to reject the null hypotheses. Follow-up tests were conducted in a post-hoc investigation of other significant effects.

Immediate Posttest Findings: Hybrid Visual as the Method of Integrating Abstract and Realistic Visualization

In the analysis of variance with the four repeated measures, when the hybrid visual was the method of integrating abstract and realistic visualization, the D, BC, BJ and CJ effects produced significant F ratios.** In the analysis for the total criterion test scores only, the D and BC effects were significant. Follow-up tests were conducted on these means only.

As expected, tests on the main means of D averaged over all four tests, as well as for the total criterion test scores, indicated that high general ability students achieved significantly

* Tables 1-10 in Appendix A present the standard scores for the immediate and delayed posttests.

** Significance of tests on means was at the .05 level, except where noted otherwise.

higher scores than medium and low ability students.* Similarly, medium general ability students achieved significantly higher scores than low ability students.

Tests on the BC means, averaged over all four tests, as well as for the total criterion test scores, indicated that when abstract visualization accompanied the instruction, students receiving externally-paced instruction achieved significantly higher scores than students receiving self-paced instruction.

Tests of the BJ means yielded no significant differences.

Tests on the CJ means indicated that students receiving self-paced instruction achieved significantly higher scores on the identification test than students who received externally-paced instruction. The results suggested these specific findings:

1. When abstract visualization accompanied instruction, externally-paced instruction was more effective than self-paced instruction, for all criterion tests and all levels of general ability.

2. Self-paced instruction was more effective than externally-paced instruction for the identification test, regardless of the type of visualization or level of general ability.

Immediate Posttest Findings: Both Types of Visuals Used Together as the Method of Integrating Abstract and Realistic Visualization

In the analysis of variance with four repeated measures, when both visuals used together was the method of integrating abstract and realistic visualization, the A, D, BC, and CJ effects produced significant F ratios. In the analysis for the total criterion test scores only, the A, D, and BC effects were significant. Follow-up tests were conducted on these means only.

* Significance of tests on means was at the .05 level except where noted otherwise.

Tests on the main A means, averaged over all four tests, as well as for the total criterion test scores, indicated that students who received instruction accompanied by realistic visualization achieved significantly higher scores than students who received instruction which was not accompanied by realistic visualization.

Again as expected, tests on the main D means, averaged over all four tests, as well as for the total criterion test scores, indicated that high general ability students achieved significantly higher scores than medium and low ability students. Similarly, medium general ability students achieved significantly higher scores than low ability students.

Tests on the BC means, averaged over all four tests, as well as for the total criterion test scores, yielded no significant differences.

Tests on the CJ means yielded no significant difference.

Immediate Posttest Findings: Comparison of the Two Methods of Integrating Abstract and Realistic Visualization

In the analysis with four repeated measures, when the two methods of integrating abstract and realistic visualization were compared, the C' and B'J effects yielded significant F ratios. In the analysis for the total criterion test only, the C' effect was significant.

Tests on the main C'means, averaged over all four tests, as well as for the total criterion test scores, indicated that high general ability students achieved significantly higher scores than low ability students. Similarly, medium general ability students

achieved significantly higher scores than low ability students. However, high and medium general ability scores were not significantly different.

Tests on the B'J means indicated that students receiving externally-paced instruction achieved significantly higher scores on the drawing test than students who received self-paced instruction.

The results suggested these specific findings:

1. Low general ability students achieved significantly lower scores than high and medium ability students, for all criterion measures, regardless of the type of visualization or pacing. However, high and medium ability did not differ significantly in achievement.

2. Externally-paced instruction was more effective than self-paced instruction for the drawing test.

Immediate Posttest: Discussion

The findings of the immediate posttest failed to reject the null hypothesis that the various types of visualization are equally effective:

$H_o : A_1B_1 = A_1B_2 = A_2B_1 = A_2B_2$ (Hybrid) $= A_2B_2$ (Both)

More specifically, the findings do not support the notion that the integration of abstract and realistic visualization will generally improve the effectiveness of instruction.

However, findings from the analysis in which both types of visuals were used together to integrate abstract and realistic visualization, that instruction accompanied by realistic visualization is more effective than instruction without realistic visualization, is of related interest. This effect, in conjunction with a similar

effect of the abstraction variable (B), was a necessary condition for the hypothesized additive effect of combining abstract and realistic visualization.

This finding lends general support to the "realism theories" (Dale, 1946; Morris, 1946; Carpenter, 1953) which suggest that as realism in pictures increases, so too does their instructional effectiveness. The finding may also be explained by the basic research cited by Dember (1960), Yarbus (1967), Kahneman (1973), and Haber (1973) which suggests that complex visuals serve to attract attention and increase exploration.

The same effect approached but did not reach significance in the analysis with the hybrid visual as the method of integrating abstract and realistic visualization. This failure to achieve significance may have been due to the fact that the hybrid visual contains a smaller realistic component than the complete color photo included when both types of visuals are presented together. The benefits of realistic visualization may be lost when the complete realistic visual is not used.

The finding, from the analysis with the hybrid visual as the method of integrating abstract and realistic visualization, that the presence of abstract visualization enhances externally-paced instruction, is in keeping with earlier findings by Dwyer (1972, p. 87). One possible explaning for this finding is that in externally-paced instruction students are compelled to take advantage of the edited cues in abstract visualization because of the limited time during which they may interact with them. Conversely, students receiving self-paced instruction may not

be sufficiently aroused to attend to these abstract cues when time is unlimited.

The finding from the same analysis that self-paced instruction was more effective than externally-paced instruction for the kind of learning measured by the identification test is not surprising. In fact, the same general advantage is seen for all tests, although the effect was significant only for the identification test. The ability on the part of the learner to interact with the instruction at his own rate apparently enhances the kind of learning measured by the identification test.

In the analysis with only the two methods of integrating abstract and realistic visualization, externally-paced instruction resulted in greater achievement than self-paced instruction for the drawing, identification, and the terminology test. However, only the drawing test results were significant. Apparently the integration of abstract and realistic visualization enhances externally-paced instruction to a greater extent than self-paced instruction (except for the comprehension measure). This trend lends limited support to the researcher's expectancy that integration may facilitate effectiveness. One possible explanation is that students receiving externally-paced instruction were aided in extracting relevant cues in a limited time by the presence of both abstract and realistic visualization.

The performances of high, medium and low general ability students were significantly different in the two analyses with different methods of integrating abstract and realistic

visualization. However, in the analysis comparing only the two methods of integration, the high and medium general ability groups' performances were not significantly different. This finding suggests that integration of realism and abstraction serves to reduce the difference in performance between high and medium general ability students. These students may be better able to take advantage of the integration of visualization because they can benefit more from the realistic component.

Delayed Posttest Findings: Hybrid Visual as The Method of Integrating Abstract and Realistic Visualization

In the analysis of variance with the four repeated measures, when the hybrid visual was the method of integrating abstract and realistic visualization, the D, BCJ, and BDJ effects produced significant F ratios. In the analysis for the total criterion test scores only, the D effect was significant. Follow-up tests were conducted on these means only.

The D means in the analysis with the four repeated measures were not of interest because they were involved in the significant BDJ interaction. However, tests of the D means for the total criterion test only indicated that high, medium, and low general ability students respectively each scored significantly higher scores than the next group.

In follow-up tests on the BCJ interaction, the BC means were tested at each level of J. These tests yielded no significant differences.

In follow-up tests of the BDJ interaction, the BD means

were tested at each level of J. There were no significant differences between B_1 and B_2 at a given level of general ability (D) for any criterion tests. Significant differences in the D means at given levels of B and J indicate that the presence of abstract visualization tends to increase the difference in achievement between high and low ability students.

The results suggested these specific findings:

1. High general ability students improved moderately, though not significantly on all criterion tests when abstract visualization accompanied instruction.

2. Medium general ability students improved moderately, though not significantly, on the drawing, identification, and terminology tests when abstract visualization accompanied instruction. On the comprehension test, a trivial opposite effect occurred.

3. Low general ability students' achievement declined moderately, though not significantly, on the drawing, identification, and terminology tests when abstract visualization accompanied instruction. On the comprehension test, the opposite effect occurred.

Delayed Posttest Findings: Both Types of Visuals Used Together as the Method of Integrating Abstract and Realistic Visualization.

In the analysis of variance with four repeated measures, when both visuals used together was the method of integrating abstract and realistic visualization, the A, D, and BCJ effects produced significant F ratios. In the analysis for the total criterion test scores only, the A and D effects were significant. Follow-up tests were conducted on these means only.

Tests of the main A means, averaged over all four tests,

as well as for the total criterion test scores, indicated that students who received instruction accompanied by realistic visualization achieved significantly higher scores than students who received instruction which was not accompanied by realistic visualization.

Tests on the D means, averaged over all four tests, as well as for the total criterion test scores, indicated that high general ability students achieved significantly higher scores than medium and low ability students. Similarly, medium general ability students achieved significantly higher scores than low ability students.

In follow-up tests on the BCJ interaction, the BC means were tested at each level of J. The only significant difference occurred with the comprehension test scores. These results indicated that for externally-paced instruction, students who received instruction accompanied by abstract visualization achieved significantly higher scores on the comprehension test than students who received instruction which was not accompanied by abstract visualization.

The results suggested these specific findings:

1. Students who received instruction accompanied by realistic visualization achieved significantly higher scores on all criterion measures than students who received instruction which was not accompanied by realistic visualization, regardless of the pacing or level of general ability.

2. Externally-paced instruction accompanied by abstract visualization is more effective for the kind of learning measured by the comprehension test than externally-paced instruction which is not accompanied by abstract visualization.

Delayed Posttest Findings: Comparison of the Two Methods of Integrating Abstract and Realistic Visualization

In the analysis of variance with the four repeated measures, when the two methods of integrating abstract and realistic visualization were compared, the C', B'C', and A'C'J effects yielded significant F ratios. Only the A'C'J interaction was of interest because the lower order interaction and main effect were involved in it and uninterpretable. In the analysis for the total criterion test only, the C' and B'C' effects yielded significant ratios. Accordingly, only the B'C' interaction was interpretable.

In follow-up tests on the A'C'J interaction, the A'C' means were tested at each level of J. The general trend, with one exception, was for the achievement of each ability group to improve moderately, and in one case significantly, when abstract and realistic visualization were integrated by presentation of both types of visuals simultaneously instead of by use of the hybrid visual. Low ability students achieved significantly higher scores on the drawing test when both abstract and realistic visuals were presented simultaneously. The one exception to the trend was found in the performance of the high ability students on the drawing test. The achievement of these students was higher, though not significantly, for the hybrid visual.

Tests of the A'C' means between levels of C' at each level of A' and J revealed that the presentation of both types of visuals reduced the difference in performance on the drawing test between the high and low general ability groups. No similarly

strong effect was apparent for the other criterion tests.

Tests on the B'C' means for the total criterion test scores revealed no significant differences between levels of B' at a given level of general ability (C'). Similarly, there were no significant differences between the three general ability groups at B_1'. However, at B_2' (the presence of abstract visualization) high ability students scored significantly higher than medium and low ability students.

The results suggested these specific findings:

1. With one exception, all ability groups improved moderately and, in some cases significantly, when abstract and realistic visualization were integrated by presentation of both types simultaneously instead of through use of the hybrid visual.

2. The drawing test performance of low ability students was significantly improved by use of both types of visuals, instead of the hybrid visual.

3. Use of both types of visuals reduced the difference in performance on the drawing test by high, medium and low ability groups.

4. For self-paced instruction, high ability students achieved significantly higher scores than medium and low ability students.

Delayed Posttest: Discussion

As in the immediate posttest, the findings of the delayed posttest failed to reject the null hypothesis that the various types of visualization are equally effective. However, the findings do indicate that, at least for low general ability students' performance on the drawing test, presentation of both types of

visuals is more effective than use of the hybrid visual as a means of integrating abstract and realistic visualization. This effect was also apparent, though not significant for other ability groups performing on other tests. Relatedly, both types presented together also reduced the difference in performance on the drawing test of high and low ability groups. These findings may possibly be explained by the increased amount of realistic visualization available when both types of visuals are presented simultaneously. Also, the findings are supportive of Hudgins (1977) who suggests possible advantages to a multi-stage use of abstract and realistic visualization.

The finding in the analysis in which both types of visuals were used together to integrate abstract and realistic visualization is more effective than instruction without realistic visualization is also of interest. This finding lends general support to the "realism theories" (Dale, 1946; Morris, 1946; Carpenter, 1953) which suggest that as realism in pictures increases, so too does their instructional effectiveness. The findings may also be explained by the basic research cited by Dember (1960), Yarbus (1967), Kahneman (1973), and Haber (1973) which suggests that complex visuals serve to attract attention and increase exploration. This effect was not present in the design in which abstract and realistic visualization were integrated by means of the hybrid visual. One possible explanation for this may be that the hybrid visual contains less realistic area than the total color photograph.

The effect of abstract visualization was inconsistent. In the analysis with the hybrid visual as the method of integrating

abstract and realistic visualization, high and medium general ability students benefited moderately, though not significantly on most tests from the presence of abstract visualization. However, low ability students' scores declined moderately though not significantly, on most tests when abstract visualization accompanied instruction. Some kinds of learning by low ability students may be susceptible to long term forgetting because they were not sufficiently aroused by abstract visualization.

In the analysis in which both types of visuals were presented simultaneously to integrate abstract and realistic visualization, abstract visualization significantly enhanced the effectiveness of externally-paced instruction as measured by the comprehension test. This finding is consistent with earlier findings by Dwyer (1972). Apparently, the abstract visualization enabled students to extract relevant cues which improved learning.

Conclusions

The results of both posttests suggest that designers of visualized intruction may expect to enhance its effectiveness under general conditions by inclusion of realistic visualization. Inclusion of abstract visualization cannot be expected to improve effectiveness under general conditions and should be based on consideration of pacing, general ability and type of instructional objective.

Although the integration of abstract and realistic visualization does not appear to generally improve effectiveness, it may serve to enhance externally paced instruction and may reduce the difference

in achievement between students of different general ability, particularly when both types of visualization are presented together.

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TABLE 1

IMMEDIATE POSTTEST STANDARD SCORES, DRAWING TEST

		Externally-Paced General Ability Groups			Self-Paced General Ability Groups		
		Low	Medium	High	Low	Medium	High
A_1B_1	$\bar{X}$	42.22	49.00	51.33	44.11	45.56	47.89
(Control)	s	4.52	10.61	10.19	6.74	8.53	7.08
A_1B_2	$\bar{X}$	48.11	55.22	57.89	43.67	48.11	48.78
(Line Drawing)	s	7.77	8.86	2.76	6.04	8.15	8.50
A_2B_1	$\bar{X}$	48.67	48.11	51.33	43.56	51.78	58.78
(Real Photograph)	s	10.98	8.04	10.92	9.89	8.53	11.52
A_2B_2	$\bar{X}$	43.67	59.56	58.89	41.67	49.44	58.22
(Hybrid)	s	5.55	12.00	10.98	3.54	8.95	10.02
A_2B_2	$\bar{X}$	52.22	56.33	53.56	47.44	51.78	53.56
(Both)	s	11.41	7.86	12.88	8.57	7.82	6.89

n=9

TABLE 2

IMMEDIATE POSTTEST STANDARD SCORES, IDENTIFICATION TEST

		Externally-Paced General Ability Groups			Self-Paced General Ability Groups		
		Low	Medium	High	Low	Medium	High
A_1B_1 (Control)	$\bar{X}$	42.89	48.22	51.89	48.78	43.56	52.67
	s	5.3	9.6	13.2	5.4	6.4	10.3
A_1B_2 (Line Drawing)	$\bar{X}$	48.56	54.56	58.00	43.89	47.00	47.22
	s	5.0	10.0	10.7	6.0	10.9	10.7
A_2B_1 (Real Photograph)	$\bar{X}$	49.56	50.11	54.56	43.22	50.78	57.56
	s	10.0	11.4	8.3	7.8	8.5	5.2
A_2B_2 (Hybrid)	$\bar{X}$	46.56	56.44	62.11	43.22	45.22	60.33
	s	7.5	11.6	10.5	3.0	9.0	12.1
A_2B_2 (Both)	$\bar{X}$	49.89	57.11	49.78	45.33	53.22	55.44
	s	8.6	8.7	12.3	9.4	10.7	8.6

n=9

TABLE 3

IMMEDIATE POSTTEST STANDARD SCORES, TERMINOLOGY TEST

		Externally-Paced General Ability Groups			Self-Paced General Ability Groups		
		Low	Medium	High	Low	Medium	High
A_1B_1 (Control)	$\bar{X}$	45.33	51.67	48.22	48.56	49.11	56.78
	s	6.4	7.3	11.3	8.7	9.9	8.6
A_1B_2 (Line Drawing)	$\bar{X}$	48.56	50.44	59.22	43.78	47.00	49.11
	s	6.4	7.6	14.8	6.0	11.9	7.8
A_2B_1 (Real Photograph)	$\bar{X}$	44.00	52.89	51.00	47.22	50.78	60.67
	s	7.4	9.7	12.4	5.3	10.0	7.0
A_2B_2 (Hybrid)	$\bar{X}$	44.56	55.44	60.11	41.78	50.11	58.67
	s	7.8	10.5	16.1	5.04	10.9	10.8
A_2B_2 (Both	$\bar{X}$	46.33	52.78	52.89	44.11	52.44	58.56
	s	5.8	10.7	10.4	4.7	8.3	12.1

n=9

TABLE 4

IMMEDIATE POSTTEST STANDARD SCORES, COMPREHENSION TEST

		Externally-Paced General Ability Groups			Self-Paced General Ability Groups		
		Low	Medium	High	Low	Medium	High
A_1B_1 (Control)	$\bar{X}$	44.44	51.67	50.78	47.22	51.56	53.78
	s	4.7	8.8	10.8	8.5	6.3	12.0
A_1B_2 (Line Drawing)	$\bar{X}$	50.22	50.22	52.33	46.78	47.89	50.00
	s	6.7	10.9	14.2	6.6	8.0	5.3
A_2B_1 (Real Photograph)	$\bar{X}$	45.78	49.22	56.22	50.22	49.44	58.66
	s	9.1	9.7	9.9	9.2	8.4	15.3
A_2B_2 (Hybrid)	$\bar{X}$	44.33	50.78	54.56	42.67	49.78	57.78
	s	4.7	10.6	16.3	5.4	8.4	12.4
A_2B_2 (Both)	$\bar{X}$	45.89	51.00	53.44	46.44	51.44	59.89
	s	8.4	7.4	8.6	6.1	12.3	9.8

n=9

TABLE 5

IMMEDIATE POSTTEST STANDARD SCORES, TOTAL CRITERION TEST

		Externally-Paced General Ability Groups			Self-Paced General Ability Groups		
		Low	Medium	High	Low	Medium	High
A_1B_1 (Control)	$\bar{X}$	42.22	50.11	51.00	46.44	46.44	52.89
	s	4.3	7.9	11.8	6.4	4.3	9.4
A_1B_2 (Line Drawing)	$\bar{X}$	48.78	53.44	58.56	43.22	47.00	48.44
	s	5.3	8.7	11.7	5.9	10.0	8.6
A_2B_1 (Real Photograph)	$\bar{X}$	46.78	49.89	53.89	44.89	50.78	60.78
	s	10.3	9.2	10.9	7.3	9.2	9.1
A_2B_2 (Hybrid)	$\bar{X}$	43.78	57.22	61.00	40.67	48.33	60.67
	s	5.3	11.1	14.8	2.3	9.3	12.2
A_2B_2 (Both)	$\bar{X}$	48.78	55.56	53.11	45.11	52.67	57.89
	s	6.5	9.0	12.0	5.4	9.1	5.3

n=9

TABLE 6

DELAYED POSTTEST STANDARD SCORES, DRAWING TEST

		Externally-Paced General Ability Groups			Self-Paced General Ability Groups		
		Low	Medium	High	Low	Medium	High
A_1B_1 (Control)	$\bar{X}$	42.89	51.11	50.22	46.11	45.78	54.22
	s	3.59	10.90	10.35	7.15	6.53	7.69
A_1B_2 (Line Drawing)	$\bar{X}$	49.89	51.89	57.44	41.56	49.11	53.44
	s	9.74	7.77	9.80	2.88	10.41	11.35
A_2B_1 (Real Photograph)	$\bar{X}$	50.11	49.89	51.67	45.89	52.11	57.11
	s	8.58	7.29	9.38	9.55	9.49	13.06
A_2B_2 (Hybrid)	$\bar{X}$	40.89	53.22	58.89	41.22	50.78	59.44
	s	2.15	9.85	13.47	2.86	10.35	13.05
A_2B_2 (Both)	$\bar{X}$	51.22	53.33	53.78	47.11	51.67	55.22
	s	10.78	8.17	12.36	6.58	7.40	14.21

n=9

TABLE 7

DELAYED POSTTEST STANDARD SCORES, IDENTIFICATION TEST

		Externally-Paced General Ability Groups			Self-Paced General Ability Groups		
		Low	Medium	High	Low	Medium	High
A_1B_1 (Control)	$\bar{X}$	46.00	49.78	48.67	48.11	45.56	52.22
	s	5.92	16.84	13.76	8.80	5.50	8.18
A_1B_2 (Line Drawing)	$\bar{X}$	44.33	50.67	58.67	47.33	45.56	56.89
	s	3.81	7.52	12.84	5.81	6.46	8.59
A_2B_1 (Real Photograph)	$\bar{X}$	52.78	49.44	53.78	45.56	50.33	55.11
	s	12.71	5.27	12.01	8.71	10.61	13.49
A_2B_2 (Hybrid)	$\bar{X}$	45.33	51.11	55.22	45.89	51.00	58.78
	s	3.28	8.91	14.11	8.55	10.05	11.33
A_2B_2 (Both)	$\bar{X}$	48.22	52.33	53.00	45.33	51.78	61.67
	s	5.93	8.63	12.01	6.86	7.89	13.45

n=9

TABLE 8

DELAYED POSTTEST STANDARD SCORES, TERMINOLOGY TEST

		Externally-Paced General Ability Groups			Self-Paced General Ability Groups		
		Low	Medium	High	Low	Medium	High
A_1B_1	$\bar{X}$	44.56	53.33	50.44	44.11	47.00	50.56
(Control)	s	5.88	11.47	7.09	8.36	8.96	12.51
A_1B_2	$\bar{X}$	44.11	45.67	55.89	43.89	51.67	54.67
(Line Drawing)	s	3.22	6.76	16.79	5.58	7.87	6.82
A_2B_1	$\bar{X}$	46.00	48.33	58.56	48.11	52.78	58.00
(Real Photograph)	s	5.29	9.19	16.79	9.89	9.56	10.81
A_2B_2	$\bar{X}$	44.78	50.89	49.00	45.89	45.67	61.56
(Hybrid)	s	6.22	8.24	8.05	4.43	6.95	12.61
A_2B_2	$\bar{X}$	46.56	51.00	52.89	46.33	47.44	67.22
(Both)	s	8.32	9.03	6.85	7.04	7.88	11.27

n=9

TABLE 9

DELAYED POSTTEST STANDARD SCORES, COMPREHENSION TEST

		Externally-Paced General Ability Groups			Self-Paced General Ability Groups		
		Low	Medium	High	Low	Medium	High
A_1B_1 (Control)	$\bar{X}$	41.78	45.67	50.78	44.33	49.89	51.78
	s	5.04	5.68	8.57	6.20	11.19	9.19
A_1B_2 (Line Drawing)	$\bar{X}$	51.56	49.56	56.78	50.00	47.33	50.56
	s	10.08	4.93	17.69	4.64	16.19	8.97
A_2B_1 (Real Photograph)	$\bar{X}$	45.67	46.89	51.56	45.44	53.67	55.56
	s	8.34	7.87	10.97	9.22	10.46	16.00
A_2B_2 (Hybrid)	$\bar{X}$	47.00	48.89	52.33	46.44	47.67	57.67
	s	7.40	10.08	7.19	7.35	10.19	10.36
A_2B_2 (Both)	$\bar{X}$	51.56	51.56	51.77	46.67	50.67	66.33
	s	7.94	13.54	8.50	10.04	11.64	12.48

n=9

TABLE 10

DELAYED POSTTEST STANDARD SCORES, TOTAL CRITERION TEST

		Externally-Paced General Ability Groups			Self-Paced General Ability Groups		
		Low	Medium	High	Low	Medium	High
A_1B_1 (Control)	$\bar{X}$	42.44	50.11	50.00	45.11	46.00	53.00
	s	3.50	12.40	10.25	7.06	6.87	8.03
A_1B_2 (Line Drawing)	$\bar{X}$	47.00	49.67	58.89	44.44	48.00	55.11
	s	6.16	5.77	15.23	4.56	10.72	9.75
A_2B_1 (Real Photograph)	$\bar{X}$	49.00	48.44	54.44	45.33	52.56	57.78
	s	9.70	5.27	12.88	9.49	10.27	13.20
A_2B_2 (Hybrid)	$\bar{X}$	42.89	51.44	55.56	43.33	48.89	61.33
	s	1.96	2.92	12.65	4.39	7.75	12.60
A_2B_2 (Both)	$\bar{X}$	49.22	52.89	53.44	45.33	50.78	64.44
	s	7.61	8.85	9.30	6.04	9.02	14.15

n=9